



Methodology for ACR-700 Atmospheric Dispersion and Dose for Site Selection

Ricky Khaloo

AECL Health Physics

Presentation to the US Nuclear Regulatory Commission

Washington DC

April 6-7, 2004



 **AECL**
TECHNOLOGIES INC.



Outline

- **Canadian Accident-Based Siting Criteria**
- **AECL Methodology for Atmospheric Dispersion and Dose For Siting (accident-based)**
- **ADDAM Computer Program**
- **U.S. Accident-based Siting Criteria-10 CFR 100 pt 11**
- **Proposed Methodologies for Determining Compliance with US accident siting criteria for Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) for ACR-700 (item 5)**



Canadian Accident-Based Siting Criteria

- **Based on AECB-1059 Single/Dual Failure Criteria Deterministic-type calculation**
 - Whole Body 5 rem (50 mSv) Single failure; 25 rem (250 mSv) dual failure, Thyroid Limits presented
 - Collective Dose limits - 10^4 man-rem and 10^6 man-rem
 - In AECB-1059, the requirement is to use worst weather existing at most 10% of the time or Pasquill condition F if local meteorology unavailable.
- **Transition to CNSC Consultative Document C6 (Rev.0 [1980] and Rev.1[1999])**
 - Dose Criteria partially based on likelihood of occurrence arguments; event classification
 - 5 classes of events
- **ACR Safety Basis document dose limits are from C6 rev.1 but event classification is ACR-specific**



Canadian Accident-Based Siting Criteria

- Required to calculate dose to most-exposed member of the critical group at, or beyond the site boundary (whichever is more severe)

Table 4.8: Dose and Release Limits⁶⁰

Requirement	Event Class				
	1	2	3	4	5
effective dose (mSv)	0.5	5	30	100	250
lens of the eye (mSv)	5	50	300	1,000	1,500
skin (mSv, averaged over 1 cm ²)	20	200	1,200	4,000	5,000
30 d emissions of liquid effluent are within the derived annual emission limits for normal operation	•	•	N	N	N

- — the limit shall be met by the worst failure sequence in the event class.

N — not required.

d — day.



Canadian Accident-Based Siting Criteria

- External cloud, inhaled (including skin absorption from tritium), and from ground deposits for a “conservative weather” scenario; no ingestion dose (interdiction assumed)
- Residence time 30 days
- No decontamination or evacuation assumed for 30 days
- Conservative weather scenario defined as any scenario from the upper decile of weather scenarios ranked according to dose
- Exclusion Zone Boundary Concept, similar to EAB in philosophy, no LPZ
- No Collective Dose Limit but Collective Doses are required to be calculated



Canadian Accident-Based Siting Criteria

- Canadian EZB established by demonstrating that for all classes of events (1-5) the applicable dose limits are met at, or beyond the boundary. Minimum EZB is the site radius at which the DOSE limits are just met.
- No concept of Bounding, Representative or Hypothetical atmospheric dispersion factors (χ/Q)
- Compliance with Dose limits
- Note that the EZB radius must also meet the normal emission dose limits; accidents are limiting



AECL Methodology for Atmospheric Dispersion and Dose For Siting

- **To comply with C6, methodology given in CAN/CSA N288.2-M91 for atmospheric dispersion and dose calculation models is used**
- **Provides models for airborne dispersion/transport**
- **Airborne concentrations and ground deposited activity**
- **Methodology for Internal Dose due to inhalation, external dose due to cloudshine and external dose due to ground deposited activity**
- **N288.2 Dose Conversion Factors based on ICRP 26/30 augmented for some age dependence**



AECL Methodology for Atmospheric Dispersion and Dose For Siting

- **Data required**
 1. **Meteorological conditions**
 2. **Site characteristics**
 3. **Release characteristics**
 4. **Receptor characteristics**
- **Receptor characteristics defined by site boundary radius, neighbouring population distribution**
- **Release characteristics from up-stream analyses (SMART, GOTHIC) and physical plant parameters**
- **Site characteristics based on identified site location, terrain**
- **Meteorological conditions - site specific**



ADDAM Computer Program

- **AECL has developed ADDAM PC-based computer program to satisfy accident dose calculation requirements**
- **Uses models in CAN/CSA N288.2-M91**
- **Calculates parameters required by C6 Rev.0/1, i.e. 90% worst dose**
- **Requires weather data collected over 1 hour or less averaging times**
- **Requires release transient from Gothic and SMART (or elsewhere) to be in same time step as weather**
- **Multiple release locations**
- **Multiple receptor locations**
- **Validated and Quality Assured**
- **Designed and written to comply with CAN/CSA N286.7**
- **Dose Conversion Factor User Option - N288.2; ICRP 71**



ADDAM Computer Program

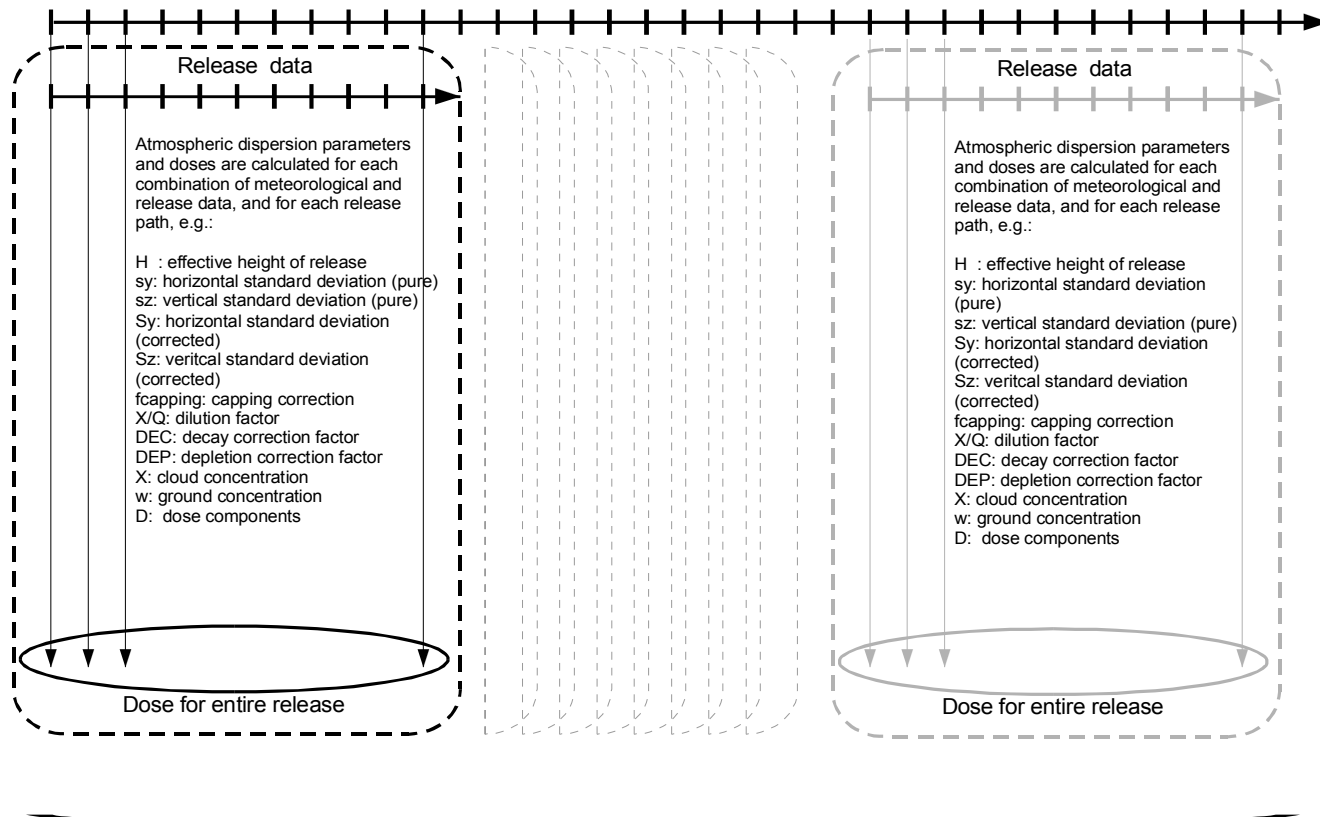
- **ADDAM uses site weather data collected over a long period of time (many years ~ 3) to determine the frequency distribution of public dose consequences of an accident, had it occurred at any time over the period of weather data collection.**



ADDAM Computer Program

Time interval at which
meteorological data is collected,
 Δt_{meteo}

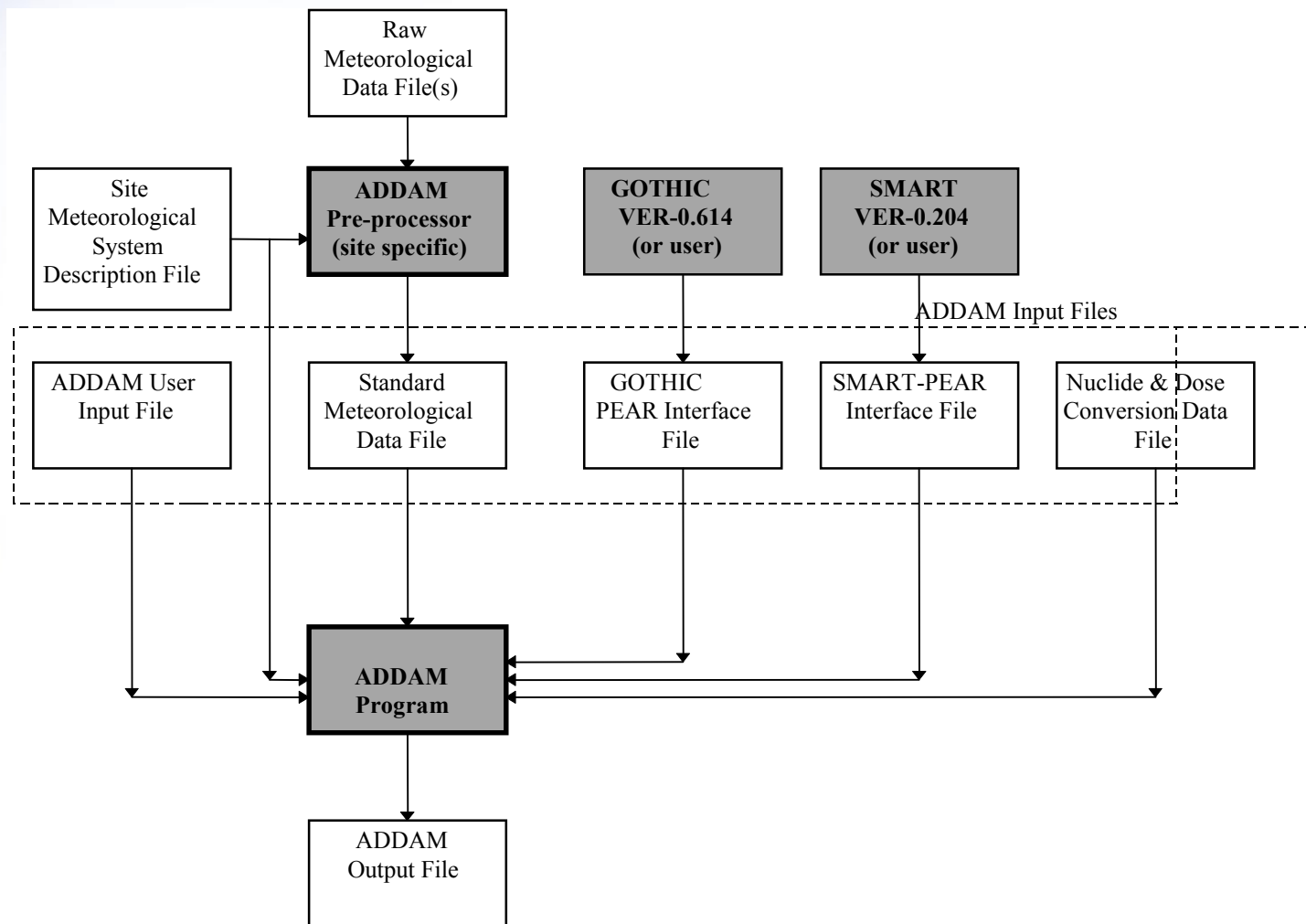
Meteorological data



Frequency distribution of dose



ADDAM Computer Program





ADDAM Computer Program

- Variable: INDIVIDUAL-DOSE
- Unit: mSv
- Statistic: P90
- Age group: ADULT
- Organ: EFFECTIVE
- Nuclide: ALL
- Release path: ALL
- Exposure path: ALL

• Radius (m)	1:N	2:NNE	3:NE	4:ENE	5:E	6:ESE	7:SE	8:SSE
•	9:S	10:SSW	11:SW	12:WSW	13:W	14:WNW	15:NW	16:NNW
• 9.14E+02	2.3	5.6	0.0	0.0	0.0	0.0	0.0	0.0
•	2.7	2.1	2.7	0.24	0.0	5.40E-02	0.15	2.1
• 1.60E+03	1.2	2.8	0.0	0.0	0.0	0.0	0.0	0.0
•	1.3	1.0	1.2	9.31E-02	0.0	1.96E-02	5.29E-02	0.97
• 3.20E+03	0.49	1.1	0.0	0.0	0.0	0.0	0.0	0.0
•	0.52	0.39	0.44	2.86E-02	0.0	5.50E-03	1.65E-02	0.33
•								
• Maximum value:	5.6							
		at sector	2	and radius	1			



U.S. Accident-based Siting Criteria

- 10 CFR100 pt 11.
- EAB - 2 hour dose TEDE (cloud shine and inhalation/skin absorption); 25 rem limit
- LPZ - entire cloud passage TEDE dose (cloud shine and inhalation/skin absorption); 25 rem limit
- (χ/Q) based on meeting dose limit at particularly defined EAB and LPZ radii using accident sets and accident specific dose limits in RG 1.183
 - Hypothetical-based on 25 rem and would be maximum permissible for defined EAB and LPZ
 - Representative - demonstrate that representative site ($y\%$) χ/Q are $<$ Hypothetical
 - Bounding - maximum of representative sites, should be $<$ Hypothetical



Proposed Methodologies for Determining Compliance with US accident siting criteria for EAB and LPZ for ACR-700 (item 5)

- **Option 1:**
 - a) **For accidents in RG 1.183 applicable to ACR, determine release characteristics (activity, heat content, efflux velocity, etc.) in 1 hour time-steps by radionuclide using AECL-accident code suite (SOURCE, GOTHIC, SMART, etc.)**
 - b) **Use ADDAM with the accident-specific characteristics and site data from 3 representative sites to calculate dose distributions and demonstrate compliance with EAB and LPZ dose limits for defined EAB and LPZ radii**
 - **Credit for coupling of transient releases with transient weather behavior. Sequential nature of weather occurrence preserved**



Proposed Methodologies for Determining Compliance with US accident siting criteria for EAB and LPZ for ACR-700 (item 5)

- **Option 2:**
 - a) **For accidents in RG 1.183 applicable to ACR, determine release characteristics (activity, heat content, efflux velocity, etc.) in 1 hour time-steps by radionuclide using AECL-accident code suite (SOURCE, GOTHIC, SMART, etc.)**
 - b) **Using dose limits in RG 1.183, and accident-specific source terms from (a) back calculate to determine hypothetical χ/Q at EAB and LPZ for defined EAB and LPZ radii. Choose maximum EAB and LPZ χ/Q as hypothetical limiting**
 - c) **Using site-specific data from 3 representative sites, calculate representative χ/Q s at EAB and LPZ for defined EAB and LPZ radii using PAVAN computer code (RG 1.145)**



Conclusion

- **Methodology to be used in determining compliance with accident siting criteria for EAB and LPZ for ACR-700 will be as per NRC requirements (e.g., option 2 items a) and b) on previous slide)**



 **AECL**
TECHNOLOGIES INC.